Hydrology and Some Effects of Urbanization on Long Island, New York

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The Precipitation Regime of Long Island, New York

By J. F. MILLER *and* R. H. FREDERICK

HYDROLOGY AND SOME EFFECTS OF URBANIZATION ON LONG ISLAND, NEW YORK

GEOLOGICAL SURVEY PROFESSIONAL PAPER 627-A

Prepared in cooperation with the New York State Department of Conservation, Division of Water Resources; the Nassau County Department of Public Works; the Suffolk County Board of Supervisors; and the Suffolk County Water Authority

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FOREWORD

Long Island, which extends from the southeastern part of the mainland of New York State eastward about 120 miles into the Atlantic Ocean, has a total area of about 1,400 square miles. (See fig. 1.) Two boroughs of New York City, Kings and Queens Counties, occupy slightly less than 200 square miles of the western part of the island and have a combined population of more than 4.5 million people. Nassau and Suffolk Counties have areas of about 290 and 920 square miles, respectively, and had a combined population of about 2.5 million people in 1965.

Although the New York City part of Long Island derives most of its water supply from surface-water sources in the Delaware and Hudson River basins, the people of Nassau and Suffolk Counties derive their entire water supply from wells tapping the underlying ground-water reservoir. Because of present large demands on the local gound-water system and because of the prospect of increased demands as Long Island continues to develop rapidly, knowledge about the hydrologic system—with special emphasis on water conservation and management—is a matter of vital concern to the present population and to the millions of people who will depend on the ground water in the future.

Considerable information is available about the water resources of Long Island as a result of studies made during more than 30 years by the U.S. Geological Survey in cooperation with New York State and county agencies. Although those studies meet many of the needs for information on specific problems and areas of Long Island, better quantitative information about the islandwide hydrologic system, and the relations between the various components of the system, is needed for water-management purposes. To provide that water information, a comprehensive water-budget study is being made by the Geological Survey in cooperation with the New York State Department of Conservation, Division of Water Resources; Nassau County Department of Public Works; Suffolk County Board of Supervisors; and Suffolk County Water Authority.

The major objectives of the water-budget study are (1) to summarize and interpret pertinent existing information about the hydrologic system of Long Island and (2) to fill several gaps in the knowledge of the hydrologic system. The results of these studies are being published in a series of coordinated reports. In some of the reports, including this one, information is developed for all of Long Island; however, in others the primary area of concern is limited to most of Nassau and Suffolk Counties.

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U.S. Geological Survey, Mineola, N.Y.

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THE PRECIPITATION REGIME OF LONG ISLAND, NEW YORK

By J. F. Miller and R. H. Frederick
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ABSTRACT

Mean annual precipitation ranges from 40 to 50 inches over Long Island and averaged about 43 inches for the analysis period 1951–65. The average precipitation is greatest over the central part of the Island. This may be due to (1) greater distance of this area from the stabilizing effects of the Atlantic Ocean and Long Island Sound, and (2) its slightly higher altitude. Average warm-season and cool-season precipitation are almost equal. The number of days with precipitation equal to or less than 1.00 inch is randomly distributed geographically but shows a definite seasonal variation, being greatest in the spring and least in the fall. The number of days with precipitation of more than 1.00 inch and the amount of rain that falls on such days are both highly correlated with average seasonal and monthly precipitation. About 5–10 percent of the water equivalent of cool-season precipitation is in the form of snow.

INTRODUCTION

Precipitation is the source of all the naturally occurring fresh water on Long Island (fig. 1), and its study is the logical first step in developing a better quantitative understanding of the hydrologic cycle.

Specifically, the purpose of this report is to describe (1) the areal distribution of precipitation, particularly of average annual and average seasonal precipitation, and (2) the time distribution of precipitation—for example, the average number of days in which a given amount of precipitation can be expected, and the intensity, duration, and frequency of precipitation amounts on Long Island.

The study reported herein was conducted by the U.S. Weather Bureau at the request of and with supporting services provided by the U.S. Geological Survey. The study and report preparation were financed cooperatively by the U.S. Geological Survey; New York State Department of Conservation, Division of Water Resources; Nassau County Department of Public Works;

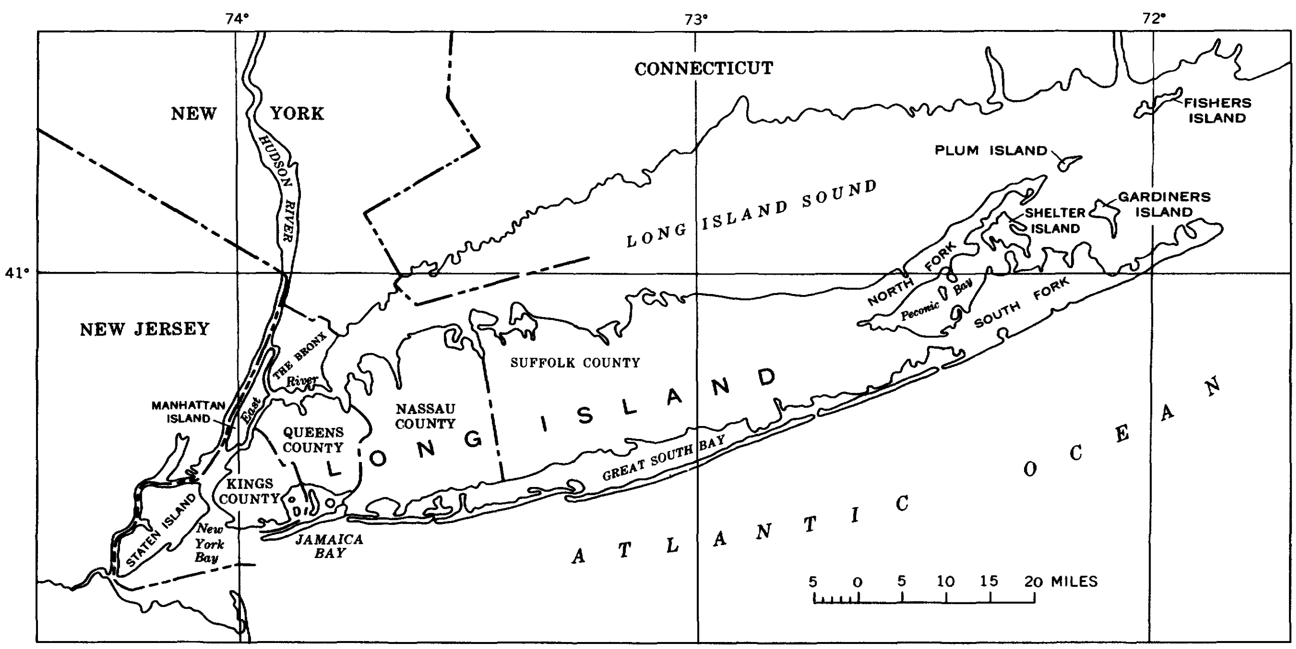


Figure 1.—Location and general geographic features of Long Island.

Suffolk County Board of Supervisors; and Suffolk County Water Authority.

FACTORS THAT CAUSE PRECIPITATION

A brief discussion of the basic factors necessary for precipitation is helpful in understanding the maps of annual and seasonal precipitation and the other diagrams and tables presented in this report. These basic factors are (1) sufficient atmospheric moisture, (2) cooling of the air, (3) condensation of water vapor into liquid or solid form, and (4) growth of condensation products to precipitation size.

Water vapor is always present in the atmosphere. The amount of moisture in the atmosphere above a given location is measured by radiosonde observations. These measurements indicate the amount of precipitation that would occur at that point if all the moisture in the atmosphere above the point condensed and fell to earth. Over any given point in the Long Island region, the quantity of atmospheric moisture ranges from a small fraction of an inch to almost 3 inches, depending on the time of year and the weather situation. Periods of no rain and clear skies are usually associated with relatively low values of atmospheric moisture. Periods of cloudiness are usually associated with relatively high values. However, some of the highest values of total atmospheric moisture occur when no precipitation is falling.

Because precipitation does not always occur with high values of atmospheric moisture, it follows that additional factors are needed to produce precipitation. One of the most important of these factors is the cooling of air. There is an upper limit to the amount of moisture that a given mass of air can hold, and that limit is a function of the temperature of the air. Thus, if the temperature of the air is lowered, its capacity for holding moisture is diminished. Air may be cooled by any one of several processes or by a combination of processes. However, cooling by reduction of pressure through lifting is the only natural process by which large masses of air can be cooled rapidly enough to produce appreciable precipitation. Once the precipitation starts, its rate and duration depend on the inflow of moisture to replace that which is condensed and precipitated.

The lifting required for precipitation can be produced either by (1) horizontal convergence of the atmosphere around a low-pressure system (commonly referred to as a low), (2) lifting along the sloping interface between two dissimilar airmasses (frontal lifting), (3) lifting due to the vertical distribution of temperature and (or) moisture within the atmosphere (atmospheric instability), or (4) forced ascent of air as it passes over mountains or hills (orographic lifting).

Another important factor in producing precipitation is the condensation process by which the water vapor is converted to liquid water droplets or, at low temperatures, into ice crystals. Saturation does not always result in condensation of the water vapor into droplets; condensation nuclei are required for this conversion. Among the most effective nuclei are certain products of combustion and salt particles evaporated from sea spray. Because such nuclei are usually plentiful in the air over a region such as Long Island, condensation usually occurs whenever the air is saturated.

For precipitation to occur after the air is cooled and condensation takes place, the water droplets or ice crystals must grow to sufficient size to overcome the upward air currents in the atmosphere and fall to the ground. Several theories have been advanced to explain the growth of cloud elements into precipitation-size drops or snowflakes. One theory involves a process that requires the presence of ice crystals in a supercooled cloud (cooled to below freezing). A vapor-pressure gradient exists between the ice crystals and the surrounding water droplets because the saturation vapor pressure over ice is less than that over water. Hence, the ice crystals grow at the expense of water droplets and, under favorable conditions, reach precipitation size. In another process, the different falling velocities of cloud elements of various sizes result in collisions between these elements and the coalescence of droplets into precipitation-size drops. Other theories for growth of cloud droplets to precipitation-size drops also have been advanced (Byers, 1965).

PRECIPITATION ENVIRONMENT OF LONG ISLAND

As mentioned above, one of the most important factors in the precipitation-producing process is the meterological situation that causes lifting and large-scale cooling of the air. Several different types of weather situations that affect Long Island cause large-scale lifting and cooling of the air and, as a result, produce precipitation.

Much of the winter precipitation on Long Island is caused by low-pressure systems which move roughly northeastward along the Atlantic Coast. The counterclockwise winds around these lows sometimes cause strong northeasterly winds along the coast which are commonly known as "northeasters." The most intense of these storms form along the Atlantic Coast near North Carolina. A new storm circulation forms as the antecedent low dissapates west of the Appalachian Mountains. As the western low fills, the new center gains in strength both from the upper level circulation moving eastward and reinforcing the surface low and from the cold air moving from above the land over the relatively warm waters of the Gulf Stream. As the cold air moves around the southern side of the low it picks up moisture from the ocean surface. Once formed, the storm moves in a path parallel to the coast of the Middle Atlantic and New England States. The resulting precipitation is largely caused by the horizontal convergence of moisture-laden air around the low.

This type of low can cause either rain or snow on Long Island depending upon the temperature. Air at temperatures below freezing usually brings snow, whereas air at temperatures above freezing in the lower several thousand feet of the atmosphere brings rain. A relatively thin layer of air with below-freezing temperatures immediately above a cold land surface can bring freezing rain (rain which freezes on the ground and other surfaces upon impact, producing a glaze of ice). Sleet results when rain, falling through air that has a below-freezing temperature, freezes before it hits the surface.

Winter precipitation over Long Island can also result when cold air sweeping southeastward around a low moving eastward along the St. Lawrence River Valley replaces a warm airmass at the surface. The resulting precipitation, which generally is in the form of light showers or snow flurries, is caused primarily by frontal lifting, although atmospheric instabilty also contributes.

Another source of winter precipitation is the type of low that moves generally northeastward along the western side of the Appalachian Mountains but comes close enough to Long Island to cause precipitation. Here the cause of precipitation is generally a combination of frontal lifting and horizontal convergence about the low.

Much of the precipitation during the summer months can be attributed to either airmass thunderstorms or to showers or thunderstorms associated with the passage of cold fronts. Airmass thunderstorms occur during periods of atmospheric instability. They develop on warm, humid days when the sun heats the lower layers of the atmosphere. The heated layers rise, and with favorable vertical temperature and moisture distribution, large cumulus clouds build to high altitudes and ultimately (usually in late afternoon or evening) become thunderstorms. Another cause of airmass thunderstorms is the radiational cooling of cloud tops at night. Usually airmass thunderstorms are more isolated and are frequently of smaller lateral extent than those associated with frontal activity.

Showers and thunderstorms associated with a cold front frequently form in lines which usually extend roughly southwest to northeast and move eastward or southeastward. Here, the heating and lifting caused by the sun is augmented by a physical lift given to the warm, humid air as colder, denser air wedges underneath it. This type of storm usually is preceded by a southerly wind and is followed by a wind with a west-to-north component after the front passes.

Storms of tropical origin commonly cause large quantities of precipitation. The precipitation from these storms is almost completely the result of horizontal convergence, although atmospheric instability within the circulation of the storm is also a contributing factor. Tropical cyclones that affect Long Island form over the tropical water of the Atlantic Ocean, the Carribean Sea, or the Gulf of Mexico. At lower latitudes they tend to move westward but then they usually curve northward and occasionally continue in a northeastward direction.

Tropical cyclones can occur at any time of the year but occur with greatest frequency during the months of June–November and thus can contribute significant amounts of precipitation during either the warm season (April–September) or the cool season (October–March).

Although the frequency of tropical storms that cross Long Island is small—16 out of 740 tropical cyclones that have occurred in the North Atlantic since 1871 (Cry, 1965)—they have produced large amounts of precipitation. Some of the more noteworthy hurricanes that affected the Island were the unnamed hurricane in September 1938, Hurricanes Carol in August 1954, Diane in August 1955, and Donna in September 1960. Other hurricanes whose centers passed either east or west of Long Island were sufficiently close for the rain area from the storm to extend over the Island. Some representative 1- and 2-day precipitation amounts that occurred on Long Island in association with hurricanes are listed in table. 1.

Of the four methods of lifting air sufficiently to cool it to the point of producing precipitation, the only one which has not been mentioned in connection with storms over Long Island is orographic lift. The highest altitudes on Long Island are about 400 feet, which is not generally considered to be sufficient lift to cause precipitation. However, in certain storms where the air is saturated throughout the lowest layers of the atmosphere, there appears to be some orographic effect from the Long Island hills. This is discussed more fully in a later section.

AVAILABILITY AND EVALUATION OF PRECIPITATION DATA

For this study, known data sources were inventoried to obtain all precipitation records on Long Island and vicinity during the period October 1940–September 1965. The basic-data network consisted of precipitation stations for which records were published by the U.S. Weather Bureau (1950–65). Additional unpublished

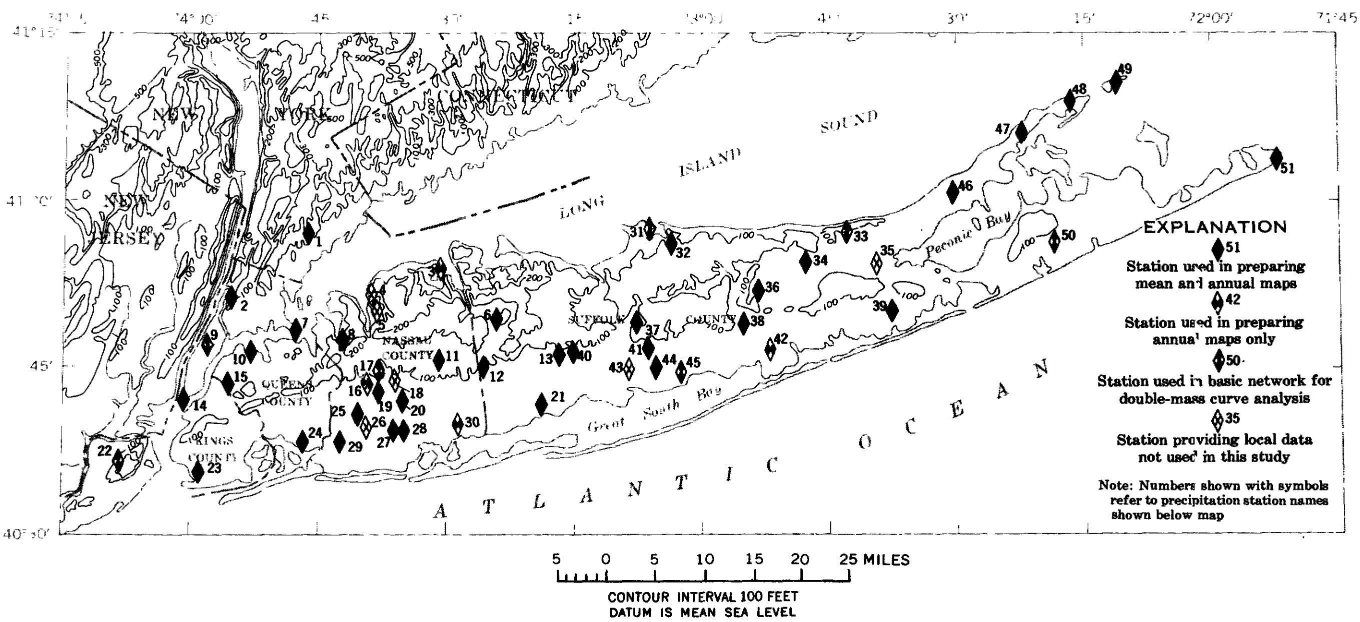
TABLE 1.—*Representative 1- and 2-day precipitation amounts associated with hurricanes for stations on Long Island, N.Y.*

Storm name	Date	Station	Amount (inches) 1 day	Amount (inches) 2 days
None	9–21–38	Bridgehampton	4.32	4.92
		Setauket	4.25	8.23
		Mineola	4.40	6.74
		Patchogue	4.22	7.91
Carol	8–31–54	Bridgehampton	4.09	4.09
		Cutchogue	3.46	3.65
		Mineola	3.09	3.27
		Riverhead Research	3.30	3.30
Edna	9–11–54	Bridgehampton	7.46	7.46
		Cutchogue	5.54	5.94
		Lake Ronkonkoma	6.03	6.03
		Mineola	4.50	5.35
		Patchogue	5.70	5.70
Connie	8–13–55	Bridgehampton	3.17	4.72
		Mineola	8.20	10.74
		New York Laurel Hill	7.24	9.60
		Hempstead-Malverne	5.12	10.13
Diane	8–19–55	Bridgehampton	2.79	4.60
		New York Laurel Hill	1.35	1.96
Donna	9–12–60	Bridgehampton	3.09	3.31
		Freeport	5.82	7.99
		Hempstead-Malverne	4.79	6.71
		Lake Ronkonkoma	5.60	7.49
		Mineola	4.99	6.04
		Riverhead Research	5.96	6.36
		Setauket	5.27	6.68

data were obtained from the U.S. Geological Survey for stations which were operated by individuals, firms, and local governmental agencies but which were not part of the official Weather Bureau network.

Of the 41 stations (fig. 2) whose records were considered adequate to make an estimate of a mean value, 31 were active in 1965. Four additional stations had 1 or 2 years of record by 1965, and three others had fragmentary records for brief periods prior to 1965. The gage exposure at all these stations was examined by field inspection, largely by Geological Survey personnel, and field sketches were prepared of the observation sites. These field sketches provide a permanent record of the sites at a particular time and were used to compare qualitatively the physical characteristics of the individual stations and to determine if these sites should show any particular bias in observations. Figure 3 shows the field sketch for Yaphank, Long Island, N.Y., as an example of the type of exposure of the stations used.

None of the gages was considered to have an exposure so poor that its data would significantly bias estimates of the precipitation. For precipitation stations discontinued before 1965, the original records of the Weather



1. Larchmont 2W
2. New York University
3. Center Island
4. Garvies Point
5. Glen Head
6. Huntington Station
7. Fort Schuyler
8. Manhasset
9. Central Park
10. La Guardia Airport
11. Hicksville
12. Farmingdale
13. Pine Aire
14. New York W80
15. Laurel Hill
16. Mineola 2W
17. Mineola
18. Mitchell Air Force Base
19. Hempstead-Garden City
20. Uniondale
21. Babylon
22. Westerleigh
23. Avenue V Brooklyn
24. Kennedy Airport
25. Hempstead-Malverne
26. Rockville Center
27. Freeport-Baldwin
28. Freeport
29. Valley Stream
30. Seaford
31. Setauket
32. Port Jefferson
33. Riverhead Research
34. Calverton
35. Riverhead
36. Upton
37. Lake Ronkonkoma
38. Yaphank
39. Suffolk County Air Force Base
40. Brentwood
41. MacArthur Airport
42. Shirley
43. Oakdale
44. Sayville
45. Patchogue 2W
46. Cutchogue
47. Greenport
48. Orient
49. Plum Island
50. Bridgehampton
51. Montauk Point

FIGURE 2.—Topography and location of precipitation stations.

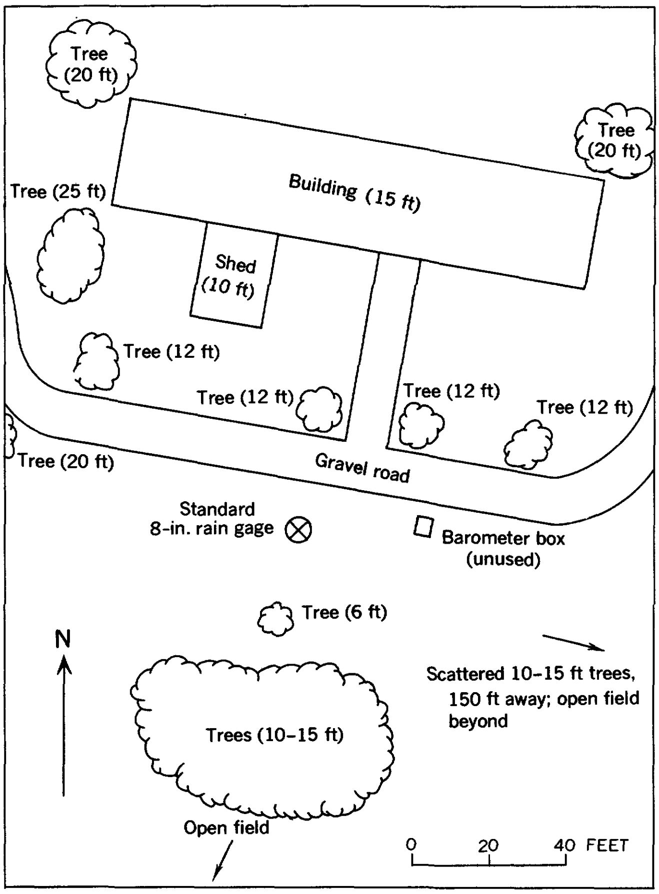


FIGURE 3.—Precipitation-gage exposure at Yaphank.

Bureau substation inspector were examined to determine the type of exposure and any indication of possible bias. Available Weather Bureau and Geological Survey records concerning these gages were then examined to detect any changes in location or exposure during the past 25 years.

Although these surveys failed to reveal any stations where changes in location or environment would affect the catch of the precipitation gage, further investigation was deemed desirable. One procedure for testing data for changes of this type is double-mass-curve analysis (Kohler, 1949; Weiss and Wilson, 1953). This method of testing precipitation data is based on a procedure that compares the cumulative annual or seasonal precipitation at the station to be tested with the concurrent cumulative values of precipitation at a group of base stations. In this method of analysis, the base group should comprise at least 10 stations in the general region, and the base stations should have precipitation environments similar to that of the test station. A straight-line plot for the entire period of record indicates that the data from the station being tested vary proportionally with the data from the base group, and therefore (1) the precipitation-gage exposure was not changed or (2) if it was changed, the change did not affect the precipitation catch. A series of straight-line segments indicates that the proportionality between the data being tested and the data from the base stations varies during the period of record. This suggests that the precipitation-gage exposure has changed either because of a change in location of the gage or because of a change in the environment surrounding the gage. If either type of change has occurred, the data from that station should either be used as two or more separate records or it should be adjusted to provide the equivalent of a homogeneous record for the entire period.

Five stations on Long Island, one on Staten Island, and one on Manhattan Island were used in the basic network (fig. 2). These stations had complete records for the period 1941–65, and had undergone little or no change in location or exposure. Three additional stations in coastal New England and New Jersey (Westbrook, Conn., 15 miles north; Rahway, N.J., 15 miles west; Long Branch, N.J., 20 miles south) were chosen to complete the 10-station basic network. These stations were carefully selected for the similarity of precipitation characteristics in relation to those of the Long Island stations. Each station was tested by the double-mass-curve technique with the other nine stations serving as the base network. This procedure disclosed no detectable variations among these stations. Double-mass curves were then prepared in which data from the remaining stations were plotted against data from this base network of 10 stations, both for the annual water-year periods and for the October–March and April–September periods. (The water year is the 12-month period beginning on October 1 and ending on September 30; it is designated by the calendar year in which it ends.) Figure 4 shows the double-mass curve for Brentwood, N.Y. No adjustment was considered necessary for this station. Of the stations used to develop the mean precipitation maps, data from only two needed minor adjustments.

A few of the "non-Weather Bureau" gages were of 3- or 4-inch diameter, as contrasted to the 8-inch standard gage used by the Weather Bureau, and these raised a question of comparability of the catches in the different-sized gages. The station at Yaphank, where both 4- and 8-inch gages were operated for a period of slightly more than 6 years, provided data for evaluating the possible effects of gage diameter. Figure 5 shows a graphical comparison of the monthly totals from the two gages. That graph, as well as a test of the means of the monthly totals from these two gages, showed no significant difference in gage catches. Therefore, in this study, data from the smaller gages were treated no differently than data from the 8-inch gages.

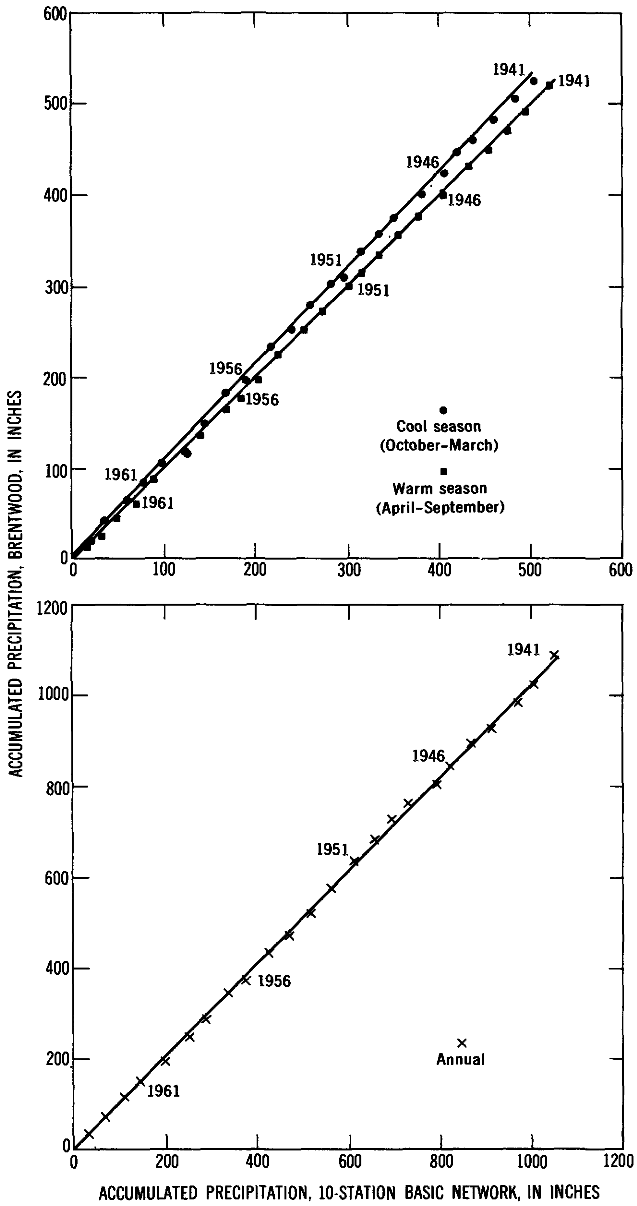


Figure 4.—Comparison of precipitation data for the Brentwood station with data from a base network of 10 nearby stations.

Records from many of the stations had short breaks because of failure of the recording instrument or because of absence of the observer. To provide the maximum amount of data possible within the 15-year period 1951–65 (the period used for a series of precipitation maps that are described subsequently), missing precipitation amounts were estimated. The procedure used was that normally followed by the Weather Bureau (Paulhus and Kohler, 1952). Many estimated amounts were for missing periods of record of a day or a few days, but amounts for entire months also were estimated when the data were missing. However, if data

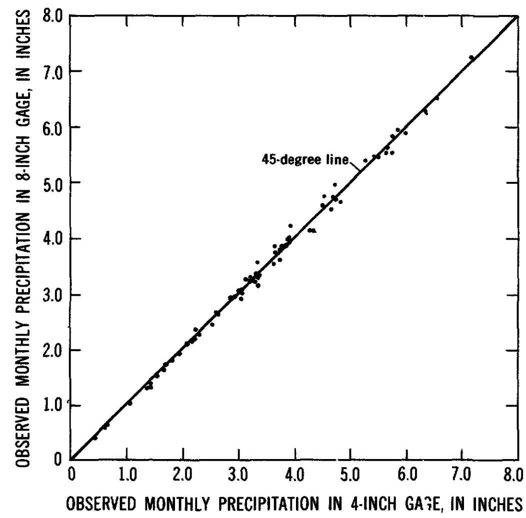


Figure 5.—Comparison of precipitation catches in the 4- and 8-inch gages at Yaphank.

were missing for a period of 3 months or more within any one season, or 6 months or more within any water year, data for that season or year were not used. In plotting the data, values containing estimated data were identified so that proper weight and evaluation could be made by the analyst. Errors introduced in the results of this study by these estimates are probably neglible and are more than offset by the additional coverage they provided.

The measurement of precipitation is subject to several sources of error. Most of the errors are individually small, but there is a general tendency for the measurements to be less than the actual precipitation. Wind effects, which are more pronounced for snow than for rain (Wilson, 1954), are the largest source of errors that tend to produce a deficient measurement. Because snow is subject to more errors in measurement than rain, an attempt was made to discover possible systematic errors or bias for stations on Long Island during periods of snow. Records for several periods of heavy snow were examined. A few stations appeared to have relatively poor records during snow periods, but objective or mathematical corrections were not possible with the limited data available. Possible errors introduced by not adjusting the less reliable snow observations were considered to be insignificant.

AREAL DISTRIBUTION OF PRECIPITATION

Precipitation is not evenly distributed over Long Island, and one of the most useful methods of describing its geographic variation is by the preparation of precipitation maps. In this method, the precipitation amounts for a specified period are plotted on a suitable base map and lines of equal precipitation are drawn. The precipitation amounts that are plotted can be daily, storm-period, monthly, seasonal, or yearly values. To estimate average conditions, the amounts for a period of several years for a specific duration can be averaged, the values plotted, and the map drawn. One advantage of this procedure is that the average depth of precipitation over the entire region, or for any area within the region, can be determined from the resulting maps.

PREPARATION OF PRECIPITATION MAPS

The density of precipitation stations on Long Island was greatest during the last few years. Although progressively fewer stations with complete or nearly complete records were available for the years previous to 1965, examination of the available data revealed that reasonable station density for the construction of mean precipitation maps could be obtained for the 15 water years, 1951–65. The station density after 1955 was about 20 percent greater than it was during the period 1951–54.

When sufficient data are available, mean precipitation maps are usually prepared for the current climatological normal period of 30 years (presently 1931–60) in accordance with the standards of the World Meteorological Organization. Using a "t" test (Dixon and Massey, 1957, p. 119), 15 stations on and near Long Island were used to compare a 15-year (1951–65) mean against the 30-year normal for the same stations. No significant difference was found, so the 15-year period, water years 1951–65, was accepted as being of sufficient length to provide realistic mean maps. In addition, the test indicated that maps prepared for this period would provide about the same results as those based on the 30-year normal period (1931–60). This is a reasonable conclusion because the wet years during the 1950's, which would tend to increase the 15-year means, were offset by the relatively dry years during the 1960's.

All stations on and near Long Island with at least 4 years of record were used to construct the mean maps. Data from stations with less than a complete 15-year record during the period 1951–65 were adjusted to a comparable period of record by correlation with the 10-station base network. For stations with a record ending just prior to the relatively dry years of the 1960's, the mean value was adjusted downward, and for stations with a short period of record during the last few years the mean was adjusted upward.

Mean October–March (cool season) and April–September (warm season) maps for the water years 1951–65 were prepared first (pl. 1). Several factors were considered subjectively in drawing the lines between the available station points on these maps. Some of those factors were: Percentage of the data estimated at a given station, length of record for each station, topography of the Island, the normal paths of storms that cause precipitation over the Island, and the temperature contrast between the land and water surfaces.

The mean water-year map was prepared as a summation of the seasonal values. The mean values were plotted for each of the 41 stations with adequate records. In addition, point amounts on a grid of 771 points over the entire Island were estimated from each of the two seasonal maps. The sum of these two seasonal values was plotted and used to prepare the annual map shown on plate 1.

Maps were also prepared for each of the 15 October–March and April–September seasons and for each water year in the period 1951–65. The method of preparation was similar to that used for the mean maps. For each year, the two seasonal maps were constructed first, and the annual map was then prepared from annual totals at each station and the seasonal grid-point values. As an example, figures 6–8 show, respectively, the October–March, April–September, and the annual map for water year 1960. The maps compiled for the other water years of the analysis period are on file in the U.S. Geological Survey office at Mineola, N.Y.

Additional maps were also constructed to show the hypothetical extreme precipitation patterns that would occur if all stations received, during the same period, precipitation in amounts equal to their maximum or minimum seasonal or annual value of record for the period 1951–65. Figures 9–11 show the patterns of maximum precipitation for the October–March, April–September, and annual periods, respectively. Here the annual map is not a composite of the two seasonal maps but was prepared independently from the maximum recorded annual values of precipitation. This was done because, for most stations, the maximum cool-season and warm-season amounts occurred during different years, and the sum of those maximum seasonal amounts would yield a hypothetical annual maximum that is unrealistically larger than any amount actually recorded. Figures 12–14 are the corresponding minimum-precipitation maps. They were prepared in a manner similar to that used for the maximum maps.

INTERPRETATION OF PRECIPITATION MAPS

The outstanding feature of the mean-precipitation maps (pl. 1) is the area of relatively high precipitation that extends roughly along the central and higher part of Long Island from Kings County through Mineola and Westbury and thence eastward along the hills in the central part of the Island (fig. 2). This area of heavy precipitation is also present on most of the seasonal and annual maps for water years 1951-65, shown typically by the maps for water year 1960 (figs. 6–8).

Although definite causes cannot be ascribed to the high precipitation in this region, two factors are probably the most important: (1) The greater distance of this central inland area from the ocean and Long Island Sound, which allows for greater surface heating and thus greater atmospheric instability, and (2) the slightly higher terrain. The first factor is most important in the warm season, when relatively cool air from over the water is heated as it passes over the Island. The second factor, although important during the warm season for giving the brief initial lift that may be sufficient to trigger airmass thunderstorms, seems to play a more important role in the winter season, when relatively warm, saturated air associated with low-pressure systems moves northward across the Island. In such cases, the few hundred feet of lift provided by the hills seem to cause additional precipitation. There are other factors that may also be important but whose role is difficult to evaluate; for example, air pollution and local patterns of air movement caused by the topography.

The geographic precipitation distribution in several recent winter storms was investigated. Radiosonde observations of atmospheric moisture content at Nantucket and New York were plotted. The air in the lowest levels of the atmosphere was categorized as "saturated," "nearly saturated," or "nonsaturated." Examination of the precipitation pattern over Long

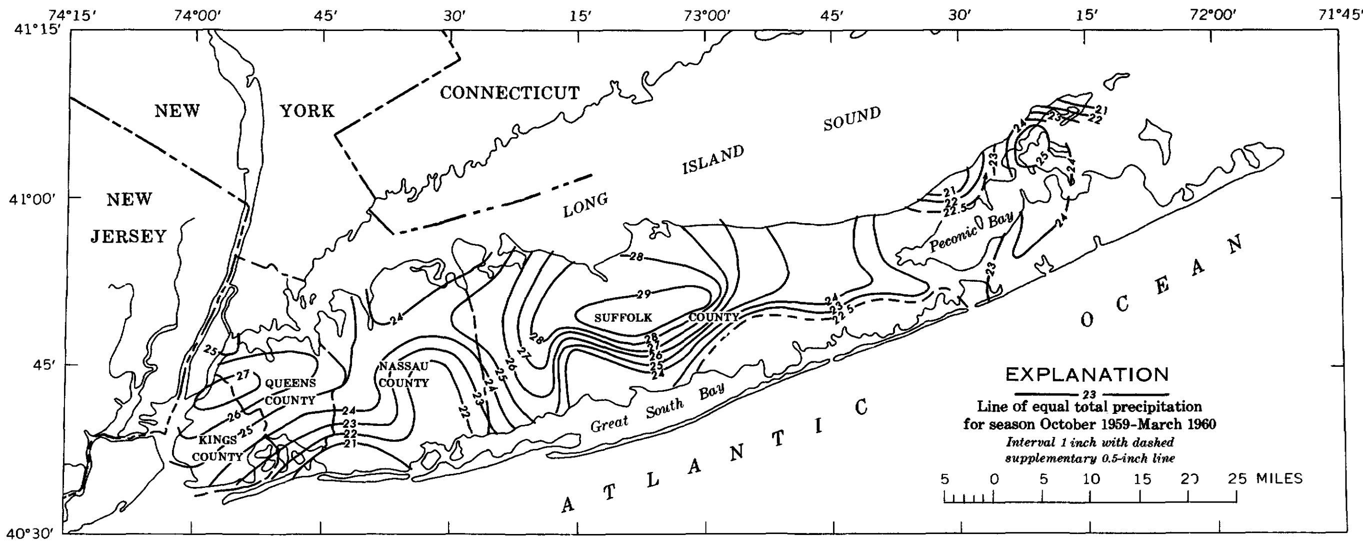


FIGURE 6.—Areal distribution of total precipitation for the season October 1959–March 1960.

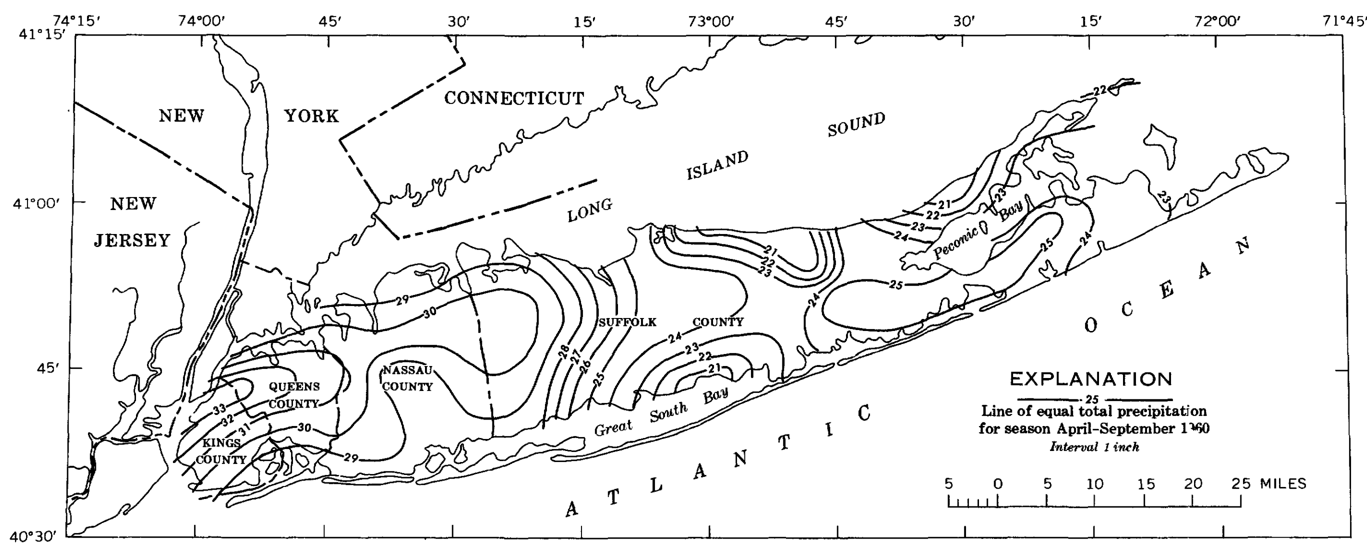


FIGURE 7.—Areal distribution of total precipitation for the season April–September 1960.

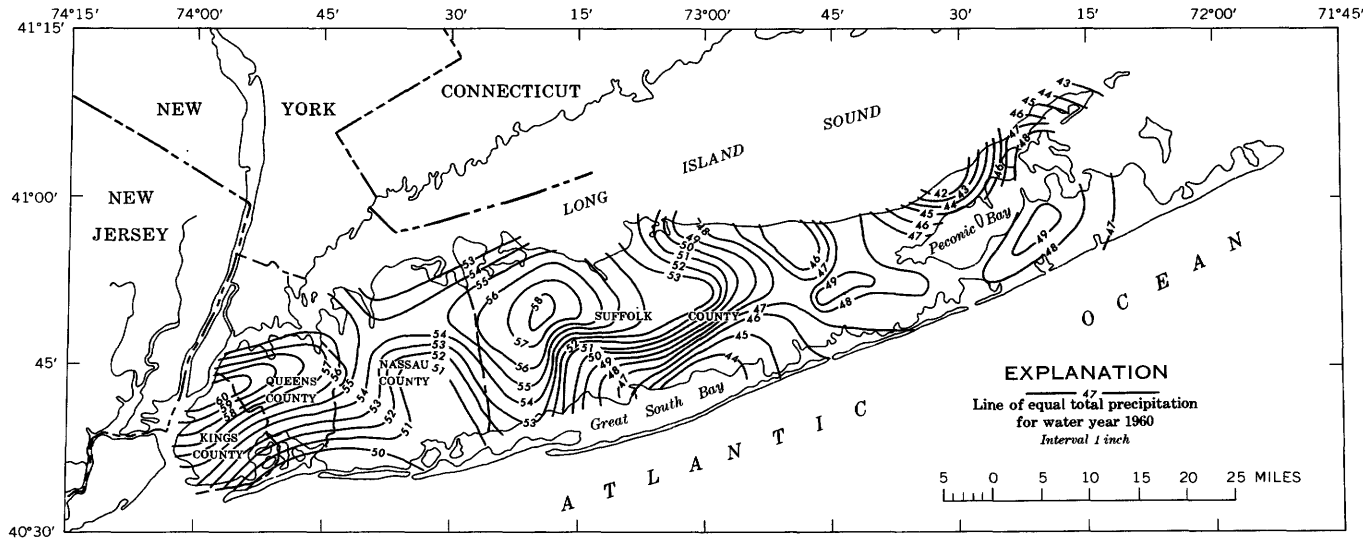


FIGURE 8.—Areal distribution of total precipitation for water year 1960.

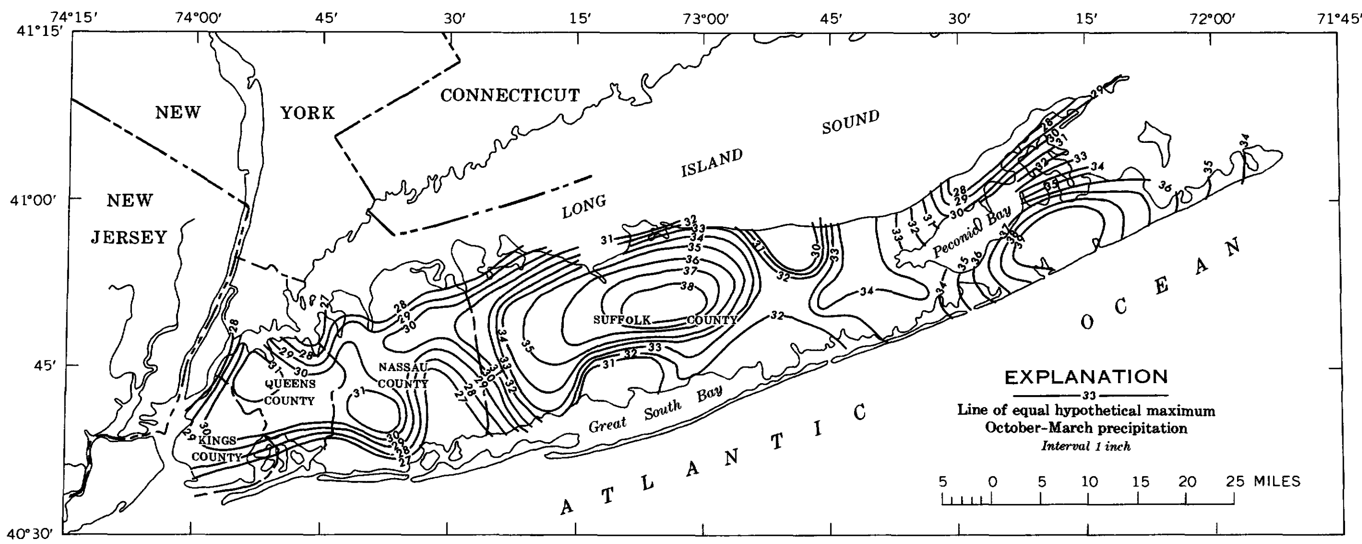


FIGURE 9.—Aerial distribution of hypothetical maximum October–March precipitation based on water years 1951–65.

Island for these storms revealed a tendency for storms with saturated air in the lowest levels to yield greater precipitation amounts over the central part of the Island, whereas storms characterized by less moisture in the lowest levels appeared to have less areal variation in precipitation amounts. These results are not conclusive, however, because the regular observation network of surface and upper-air stations was too sparse to define adequately the small-scale variations in the vertical and horizontal distribution of atmospheric moisture.

The mean precipitation during the warm season (pl. 1) shows somewhat less areal variation over the Island than during the cool season. The precipitation range across Long Island during the warm season is about 4 inches (from less than 20 to more than 23 inches), whereas the range during the cool season (pl. 1) is about 7 inches (from less than 21 to more than 27 inches). In the warm season the precipitation in the two centers of high precipitation over the western and central parts of Long Island (pl. 1) equals about 22 and 23 inches, respectively. During the cool season, although the amount in the western area of high precipitation remains nearly the same as during the warm season (about 23 in.), the amount in the central area increases to 27 inches. This increase suggests that the hills have their greatest effect in producing precipitation from storms during the cool season.

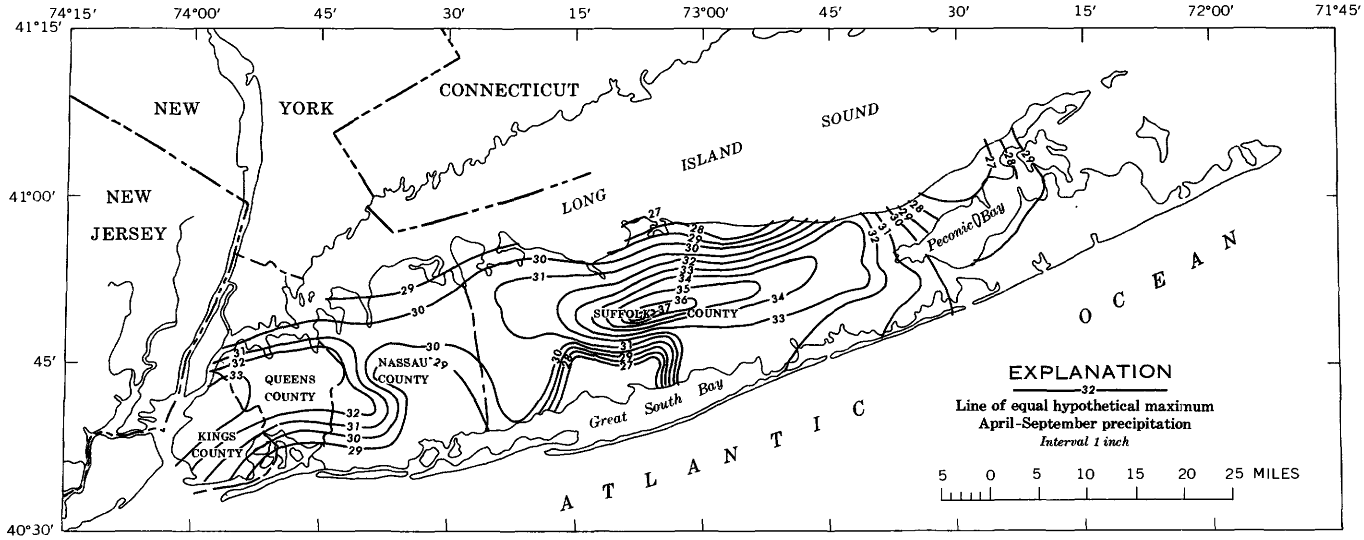


FIGURE 10.—Areal distribution of hypothetical maximum April–September precipitation based on water years 1951–65.

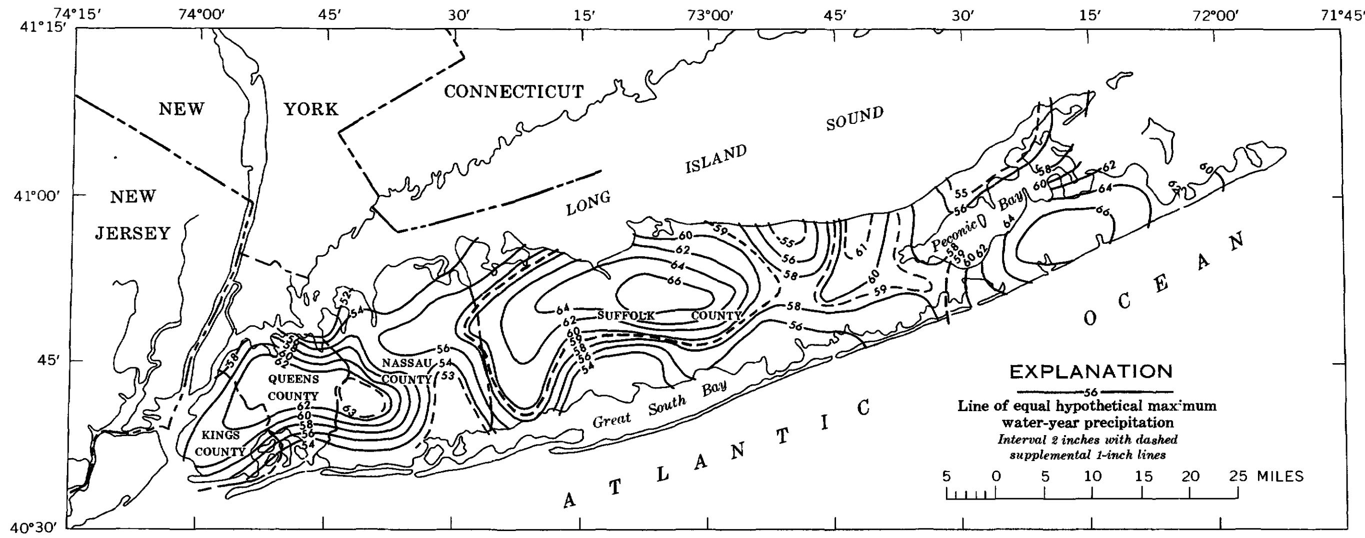


FIGURE 11.—Areal distribution of hypothetical maximum water-year precipitation based on water years 1951–65.

Figures 6–8, for water year 1960, are representative of the set of seasonal and water-year maps prepared for each of the water years 1951–65. That period included years of near normal precipitation, relatively wet years in the 1950's, and relatively dry years in the 1960's. Figures 6–8 show some variation from the mean pattern, but, in general, each figure has the same basic isohyetal pattern as that of the corresponding mean map.

The map of hypothetical maximum annual precipitation (fig. 11) shows a value of approximately 66 inches in the wettest part of the Island around Lake Ronkonkoma. On the map for the hypothetical minimum annual precipitation (fig. 14), the value for this area is only about 36 inches. As previously mentioned, these maps were plotted from the maximum and minimum yearly amounts recorded for each station, irrespective of the year in which these extreme yearly amounts occurred. An alternative way to obtain hypothetical extreme annual values would have been to combine the respective minimum and maximum values for each season, which would result in values having a considerably smaller probability of occurrence. Also, maps prepared by this latter procedure would have less probability of reflecting an actual future occurrence than would figures 11 and 14. If this procedure had been followed, the hypothetical maximum annual value in the vicinity of Lake Ronkonkoma would have been 75 inches, and

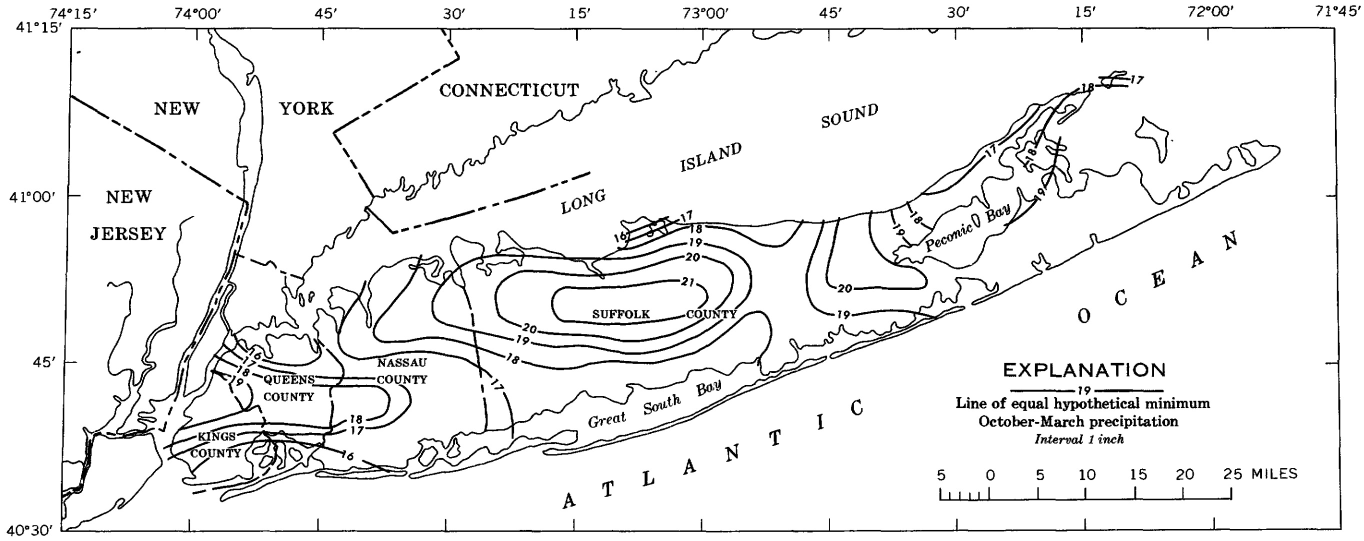


FIGURE 12.—Areal distribution of hypothetical minimum October–March precipitation based on water years 1951–65.

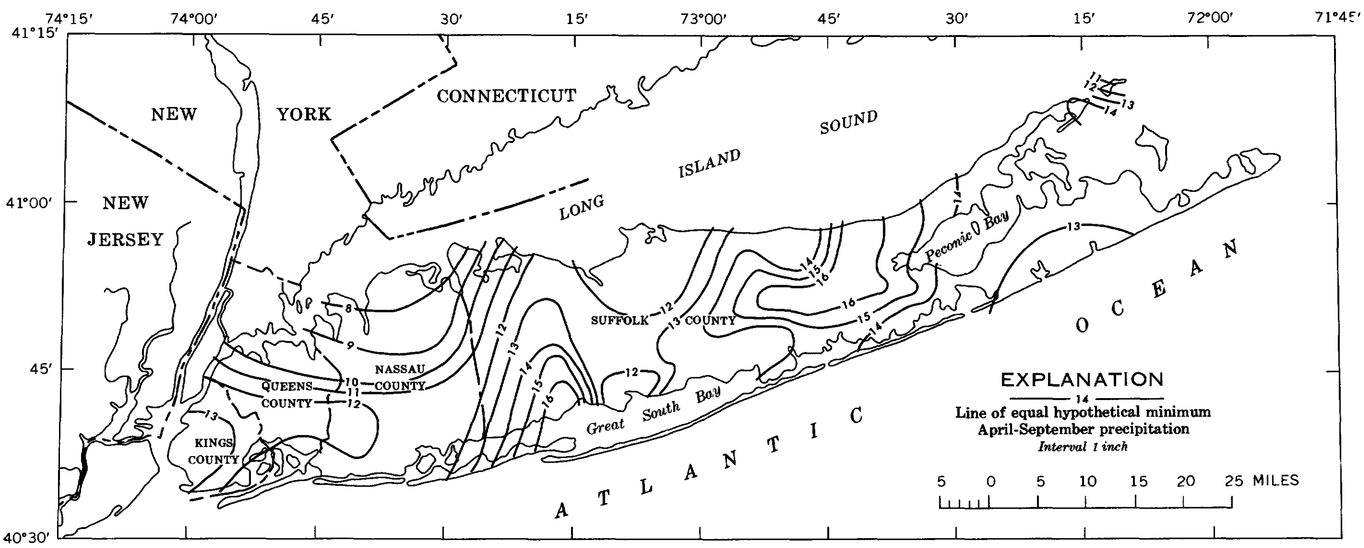


FIGURE 13.—Areal distribution of hypothetical minimum April–September precipitation based on water years 1951–65.

the minimum would have been 33 inches. An even more extreme procedure would have been to combine the maximum and minimum amounts of record for each month at each station, regardless of the year of occurrence. This procedure would have resulted in values of about 103 and 19 inches, respectively, for the hypothetical maximum and minimum annual values at Lake Ronkonkoma.

Some of the features depicted on the maps (pl. 1 and figs. 6–14) appear to be somewhat unusual, and may have resulted from minor influences in the vicinity of the gages—influences which are not apparent from inspection of the gage sites or from comparison of the gage exposures with others in the same region. Neither an examination of topographic maps nor a consideration of the broad scale meteorological controls on precipitation reveals reasons for these anomalies. Examples of such unexplained features are the region of relatively low precipitation that extends from the south coast of Long Island inland towards Hicksville and the region of higher precipitation just to the east of this trough that extends from the high center near Lake Ronkonkoma to the south coast just west of Babylon. These features are evident on plate 1 and most of the other precipitation maps. No reason could be determined for these features, which appear to be well supported by the available data. Data from additional stations in

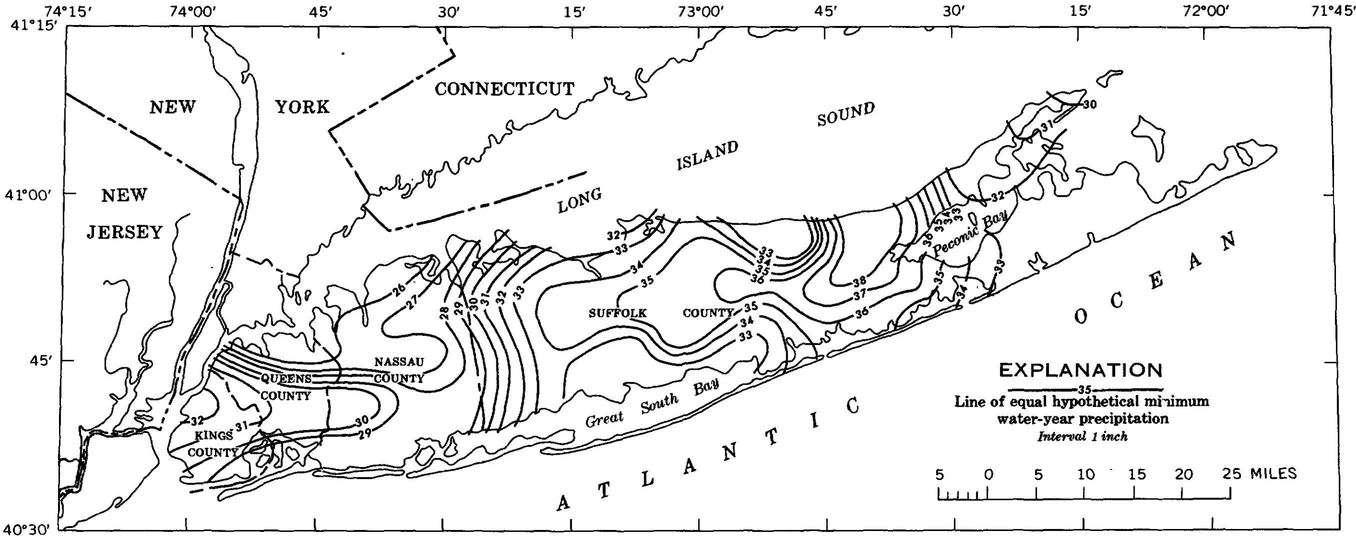


Figure 14.—Areal distribution of hypothetical minimum water-year precipitation based on water years 1951–65.

these parts of the Island might help confirm or refute the validity of these patterns.

PRECIPITATION AVERAGES

Table 2 shows the average depth of precipitation on Long Island for each water year, for the 15-year mean and extreme situations depicted on the maps (pl. 1 and figs. 9–14), and for selected probability levels. The values shown in the table for the individual years and for the 15-year mean maps (pl. 1) were determined by averaging the individual station amounts. For the extreme maps (figs. 9–14), the number and distribution of stations were not considered adequate for determination of the mean depth by averaging station values; therefore, the maps were planimetered, and the depth computed as described in Cooperative Studies Technical Paper No. 1 (U.S. Weather Bureau, 1946).

The procedure used to prepare estimates of extreme conditions over Long Island does not provide any indication of the probability of occurrence of these conditions. The length of record for which values of islandwide average precipitation can be estimated is too short to provide adequate estimates of the probability of the less likely precipitation occurrences. Therefore, to increase the length of record effectively, the average precipitation over the Island was correlated with the average precipitation from a four-station network—Bridgehampton, Freeport, New York Central Park, and Setauket. The following regression equations were developed from 23 years of concurrent records:

Annual	$Y=1.36-.98(X)$	(1)
October–March	$Y=.57-.98(X)$	(2)
April–September	$Y=.05-1.03(X)$	(3)

where Y is the islandwide precipitation and X is the four-station average precipitation. For each equation the correlation coefficient was greater than 0.95, and the ratio of the standard error of estimate to the mean of the observed islandwide precipitation was 5 percent or less. Using these equations, the writers adjusted the precipitation averages obtained from the four-station network for a 49-year period (1917–65), and applied the normal frequency distribution to the adjusted data. The 1-, 25-, 75-, and 99-percent probability levels indicate, respectively, the islandwide precipitation amount that would be equaled or exceeded 1, 25, 75, and 99 years (or seasons) out of 100.

Table 3 shows the probability that the islandwide average precipitation values in table 2, computed from the extreme seasonal and annual maps (figs. 9–14) would be equaled or exceeded. This table shows, for example, that yearly islandwide precipitation may be expected to exceed the hypothetical maximum in table 2 (59.4 in per yr) only about 4 years in every 1,000 years, but that the hypothetical minimum (32 in per yr) should be exceeded in all but about 15 years in every 1,000 years.

During the last 4 years of the precipitation-map period (1962–65), a drought occurred over much of the Middle Atlantic and New England States (Barksdale, O'Bryan, and Schneider, 1966; Fieldhouse and Palmer, 1965). The effect of this drought is clearly evident in table 2, where the amounts for each of these years are well below the mean amounts. During this drought period, the average annual precipitation was about 84 percent of the mean. The greatest deficiency occurred in the warm season, when only about 78 percent of the

TABLE 2.—*Islandwide average precipitation for seasons and water years, including the mean and hypothetical extreme values, and for selected probability levels for Long Island, N.Y., for the period water years 1951–65*

Water year	Cool-season amount (inches)	Warm-season amount (inches)	Annual amount (inches)
1951	23. 2	17. 7	40. 9
1952	29. 2	26. 3	55. 6
1953	24. 9	20. 3	45. 2
1954	20. 7	26. 3	47. 0
1955	21. 0	22. 3	43. 3
1956	27. 2	19. 4	46. 6
1957	18. 9	17. 2	36. 1
1958	28. 8	26. 3	55. 1
1959	20. 6	19. 7	40. 3
1960	24. 3	26. 3	50. 1
1961	20. 5	26. 1	46. 6
1962	20. 3	20. 0	40. 3
1963	20. 8	15. 9	36. 8
1964	20. 2	16. 4	36. 6
1965	19. 3	13. 2	32. 5
Mean [1]	22. 5	20. 9	43. 4
Maximum [2]	32. 1	30. 7	59. 4
Minimum [2]	18. 4	12. 5	32. 0
1 percent probability [3]	30. 9	32. 0	57. 4
25 percent probability [3]	24. 7	25. 1	48. 0
50 percent probability [3]	22. 2	22. 3	44. 2
75 percent probability [3]	19. 7	19. 5	40. 4
99 percent probability [3]	13. 6	12. 6	31. 6

[1] Values determined from mean maps (pl. 1).
[2] Hypothetical averages from extreme maps (figs. 9–14).
[3] Based on adjusted 4-station averages for 49 years.

TABLE 3.—*Probability that the islandwide precipitation values (table 2) estimated from the hypothetical extreme seasonal and annual maps (figs. 9–14) would be equaled or exceeded*

	Cool season	Warm season	Annual
Maximum	0. 004	0. 022	0. 004
Minimum	. 850	. 990	. 985

mean precipitation fell, whereas in the cool season about 90 percent of the mean fell. The lowest annual amount shown,[1] which was during 1965, is especially significant because the precipitation during 3 preceding years also had been below the mean for the 15-year period. In contrast, the year of the second lowest annual value, 1957, was both preceded and followed by years with precipitation above the mean. The cool season of 1957 also accounted for minimum cool-season precipitation observed during the 15-year period.

Even over a region as small as Long Island, extreme station values commonly occur in different years. Of 24 stations on Long Island whose period of record covered the entire 15-year period, 1951–65, slightly more than half experienced their minimum warm-season and annual precipitation during water year 1965 (table 4). One-fourth of the stations also experienced their minimum cool-season precipitation during this same water year. Approximately one-third received their minimum cool-season precipitation during water year 1957. Maximum annual values occurred during water year 1958 at nearly half the stations. Furthermore, nearly half the stations received their maximum cool-season and maximum annual precipitation during water year 1952.

[1] Although not included in this analysis, data for water year 1966 indicate that the islandwide average precipitation was about 1 inch less than that in 1965.

TABLE 4.—*Number of precipitation stations on Long Island, N.Y. for which maximum and minimum seasonal and annual precipitation amounts were recorded in each water year of the period 1951–65*

Water year	Number of stations receiving maximum amount for period			Number of stations receiving minimum amount for period		
	Cool season	Warm season	Annual	Cool season	Warm season	Annual
1951					1	
1952	10	4	10			
1953					1	
1954		8		4		
1955				1		2
1956	6					
1957				9	3	6
1958	8	1	12			
1959						
1960		9	2			
1961		2		3		
1962						
1963					3	1
1964				1	2	1
1965				6	14	14

Half the 24 stations experienced both their maximum cool-season precipitation and their maximum annual precipitation in the same water year. Similarly, about the same proportion of stations had their minimum warm-season and minimum annual precipitation in the same water year.

TIME DISTRIBUTION OF PRECIPITATION

NUMBER OF DAYS WITH PRECIPITATION

Mean annual precipitation on Long Island, as shown on plate 1, ranges from slightly more than 50 inches to slightly less than 41 inches. The range on the precipitation maps for the individual water years has about the same magnitude. Whatever the physical causes, this range in regional precipitation could have resulted from either (1) geographic differences in the number of days with light precipitation, (2) geographic differences in the number of days with moderate to heavy precipitation, (3) differences in the total number of days with precipitation. Differences of either type from place to place on Long Island could be significant in developing a thorough understanding of the local hydrology. Accordingly, the number of days with precipitation within various class intervals was determined for 26 of the stations (stations for which daily data were available for 10 or more years of record during the period 1951–65). For other stations that were used to develop the mean seasonal and annual precipitation maps, more than 10 years of monthly data were available, but the records contained too many periods when daily observations were not available to be useful for this part of the study.

Because most of the stations did not have a recording gage, it was necessary to tabulate the number of observational days within each class interval. An observational day is a 24-hour interval between fixed times of observation on 2 successive days. Some observers make their observations in the evening, others in the morning, and a few at midnight. Because the observations are made at a fixed time, some of them are made when precipitation is occurring, and this procedure can result in a single storm of less than 24-hour duration contributing to the amounts reported for 2 successive days. Miller and Frederick (1966) discuss this problem and give empirical relationships for converting from the mean number of observational days with precipitation above various threshold values to the corresponding number of 24-hour precipitation periods.

TABLE 5.—*Mean monthly number of days with precipitation of various class intervals and mean monthly amount of precipitation on those days*

[Average values for 26 selected stations on Long Island; see text discussion]

Class interval (range of precipitation, in inches)	J	F	M	A	M	J	J	A	S	O	N	D
Mean number of days per month												
0.01–0.25	5.6	4.9	6.2	6.5	5.9	5.1	4.6	4.8	4.3	3.9	4.4	5.3
.26–0.50	2.1	1.7	2.1	2.1	1.7	1.7	1.3	1.4	1.4	1.4	1.7	1.9
.51–1.00	1.7	1.7	1.8	1.7	2.0	1.1	1.0	1.2	1.1	1.3	1.8	1.9
Σ0.01–1.00	9.4	8.3	10.1	10.3	9.6	7.9	6.9	7.4	6.8	6.6	7.9	9.1
Mean amount of precipitation on corresponding class-interval days (inches per month)												
0.01–0.25	0.6	0.5	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.5
.26–0.50	.8	.6	.8	.8	.6	.6	.5	.5	.5	.5	.6	.7
.51–1.00	1.2	1.3	1.3	1.2	1.0	.7	.7	.8	.8	.9	1.3	1.4
Σ0.01–1.00	2.6	2.4	2.7	2.6	2.1	1.8	1.6	1.7	1.7	1.8	2.3	2.6

Observational days were tabulated for the following class intervals: 0.01–0.25, 0.26–0.50, 0.51–1.00, 1.01–2.00, 2.01–4.00, and greater than 4.00 inches. The last three class intervals were subsequently combined for seasonal rather than monthly analysis because precipitation events of the larger amounts were so few that a representative sampling could not be obtained.

Data from the 26 stations show that the geographic distribution of the days per month with precipitation less than 1.00 inch is virtually random throughout Long Island. Because the distribution is random, the best estimate for any point is the average of all points. Table 5 shows these average values for Long Island. Included in this table are the computed mean number of days per month with precipitation in the class intervals 0.01–0.25, 0.26–0.50, 0.51–1.00, and 1.00 inch or less, and the mean monthly amounts of precipitation on those days.

Figure 15 shows a plot of the data in table 5 (adjusted to a 30-day month) for the number of days in the various class intervals listed above. For all class intervals, the figure shows a seasonal trend of a maximum in the spring and a minimum in the fall. The greatest variation for any single class interval is in the number of days with precipitation of 0.01–0.25 inch.

Because this seasonal variation resembles a simple sine curve, harmonic analysis was applied as a smoothing filter (a process analogous to least-squares fitting of a straight line to linear data). The first harmonic, or single sine curve, accounts for more than 90 percent of the variation in the mean monthly precipitation.

Figure 16 (also plotted using data adjusted from table 5) shows the variation in the mean monthly amounts of daily precipitation within the various class intervals. The same general seasonal pattern is present in both figures 15 and 16. The maximum mean monthly amounts (fig. 16) occur earlier in the spring than do the maximum number of days (fig. 15). This difference can be attributed to the occurrence of late-spring storms with light amounts of precipitation (0.01–0.25 in.), which results in many rainy days but small total amounts of precipitation. Harmonic analysis of these data shows that the first harmonic accounts for only about 60 percent of the variation.

The uses of figures 15 and 16 can be illustrated by the following examples: During the month of May, the

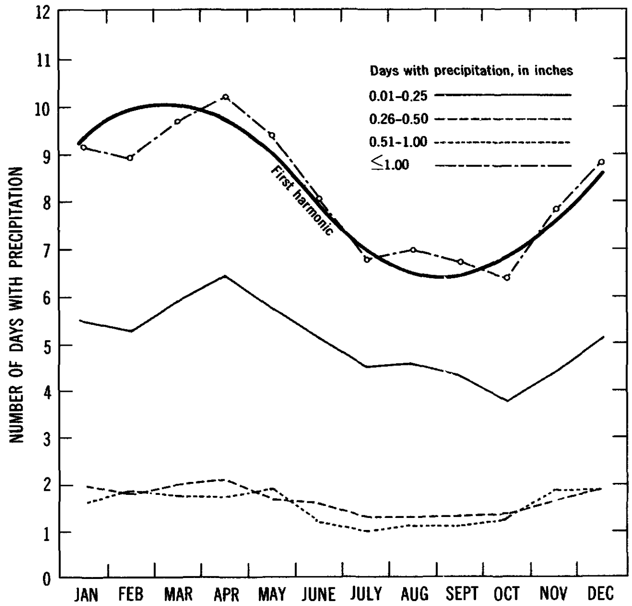


FIGURE 15.—Monthly variation in the mean number of days with precipitation of specified amounts for 26 selected stations on Long Island.

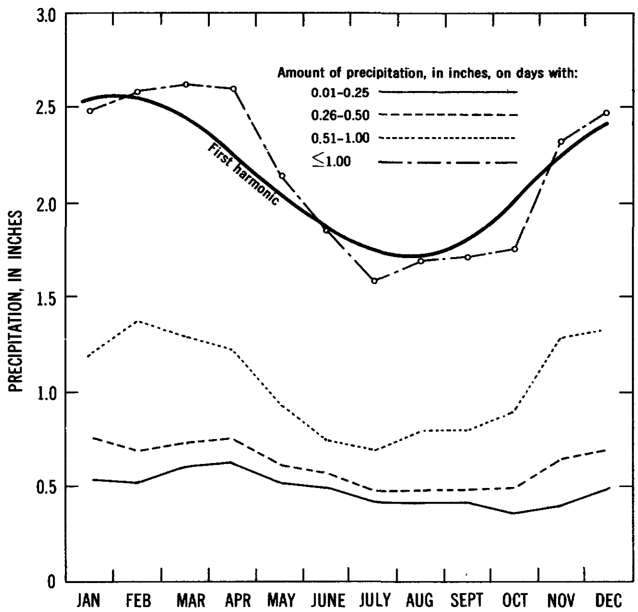


FIGURE 16.—Monthly variation in the mean amount of precipitation occurring on days with precipitation of specified amounts for 26 selected stations on Long Island.

mean number of days on which 1.00 inch or less of precipitation occurs is a little more than 9. Mean precipitation is slightly more than 2.00 inches for these 9 days, or an average of about 0.2 inch per rainy day.

The mean seasonal amount of precipitation for days with more than 1.00 inch and the number of such days were found to correlate well with the mean total seasonal precipitation. This good correlation is particularly true for the cool season. The following equation was found to relate the mean total precipitation to the average total amount of precipitation for cool-season (October–March) observational days in which more than 1.00 inch fell:

$$Y=0.87\,X-11.22, \qquad (4)$$

where Y is the average total amount of precipitation on days with more than 1.00 inch of precipitation, X the mean total seasonal precipitation. The correlation coefficient for this equation is more than 0.9, and the ratio of standard error to the mean is equal to 0.10. The equation for the number of days with precipitation greater than 1.00 inch for the cool season (October–March) is:

$$N=0.48\,X-5.28, \qquad (5)$$

where N is the average number of days with precipitation greater than 1.00 inch, and X has the meaning cited above. Equations (4) and (5) are plotted in figure 17.

The curves shown in figure 17 or equations (4) and (5) can be used to estimate the average amount of cool-season precipation on days with precipitation of 1.00 or more, as well as the average number of such days at any point on Long Island. For Northport, for example, the average cool-season precipitation estimated from plate 1 is 24.1 inches. Computations utilizing equations (4) and (5) indicate that the average cool-season precipitation falling on days with more than 1.00 inch of precipitation is 9.7 inches, and that, on the average, about 6.3 days with more than 1.00 inch of precipitation can be expected during a cool season.

Similar equations developed for the warm season (April–September) are:

$$Y=1.01\,X-11.94, \qquad (6)$$

and

$$N=0.64\,X-8.10. \qquad (7)$$

The correlation coefficient for each of these equations is approximately 0.75, and the ratio of the standard error to the mean for each equation is less than 0.10. Equations (6) and (7) are plotted in figure 18.

INTENSITY AND FREQUENCY OF PRECIPITATION

Knowledge of the intensity and probable frequency of recurrence of various precipitation events is important in several water-management considerations. On Long Island, for example, such knowledge is useful in the design of storm-water disposal systems and in making estimates of infiltration and ground-water recharge.

Precipitation-frequency values can be determined accurately with relatively short records for recurrence intervals of between 2 and 5 years; for the longer recurrence intervals, however, reliable determination of such values requires a relatively long record. Reasonably adequate long-record values are available for Long Island stations only for the 24-hour or observational-day duration. The nearest station with a long period of record for all durations from 5 minutes through 10 days is the New York City Weather Bureau Office (WBO).

In this discussion, "duration" is defined as a period of time unbounded by fixed clock hours. For example, a 1-hour duration could extend from 2:05 to 3:05 or 4:23 to 5:23 in clock time. This definition is in contrast to the concept of the "measurement interval," or "observational interval," which are terms applied to a standard observational period—for example, 2:00 to 3:00, or 4:00 to 5:00. To determine the applicability of duration data from the New York City WBO to the entire Long Island region, the results of a frequency analysis of the data at the New York City WBO were compared with results of a similar analysis for stations on Long Island. The frequency distribution used in this study was the

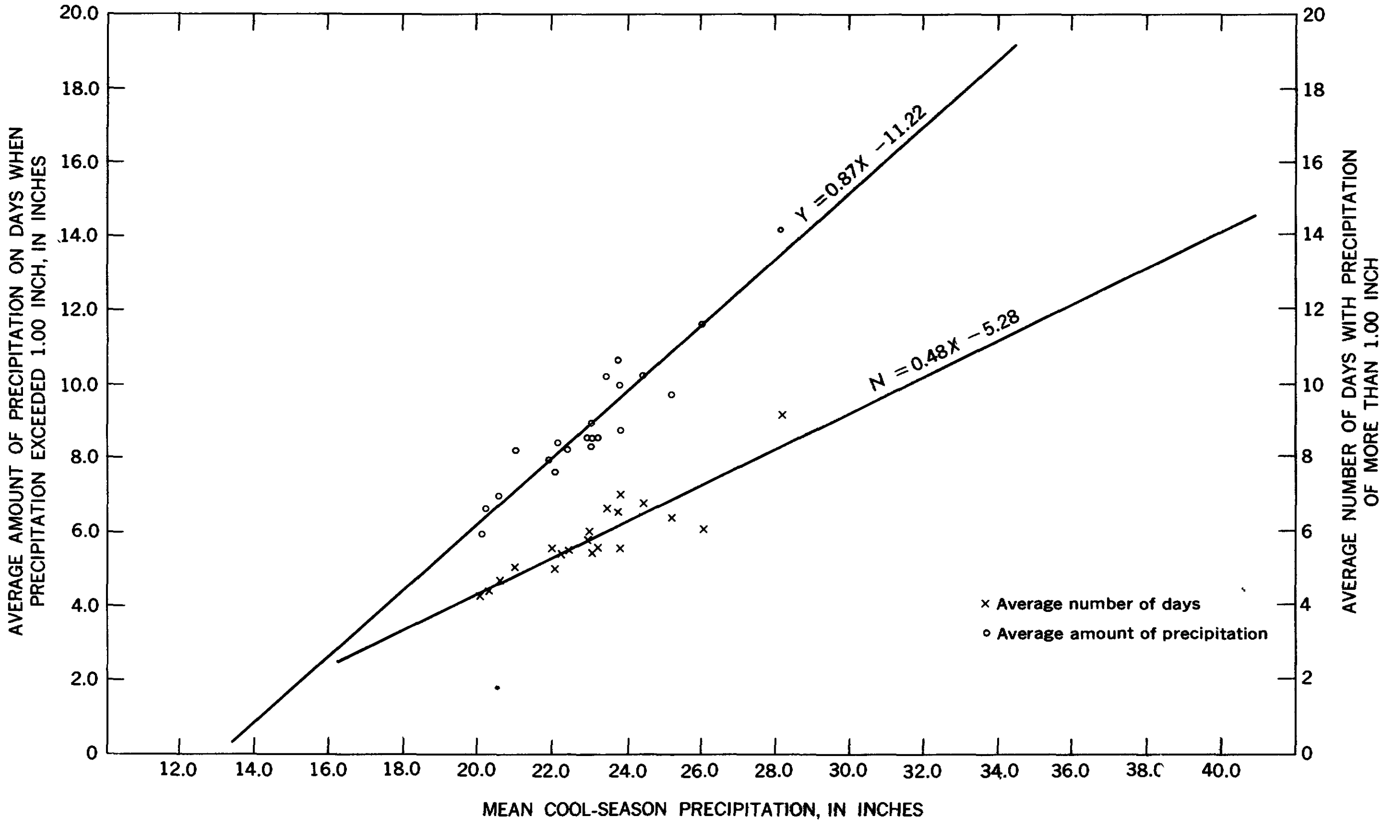


Figure 17.—Relations between mean cool-season (October–March) precipitation and the frequency and average amount of precipitation on days when precipitation exceeded 1.00 inch.

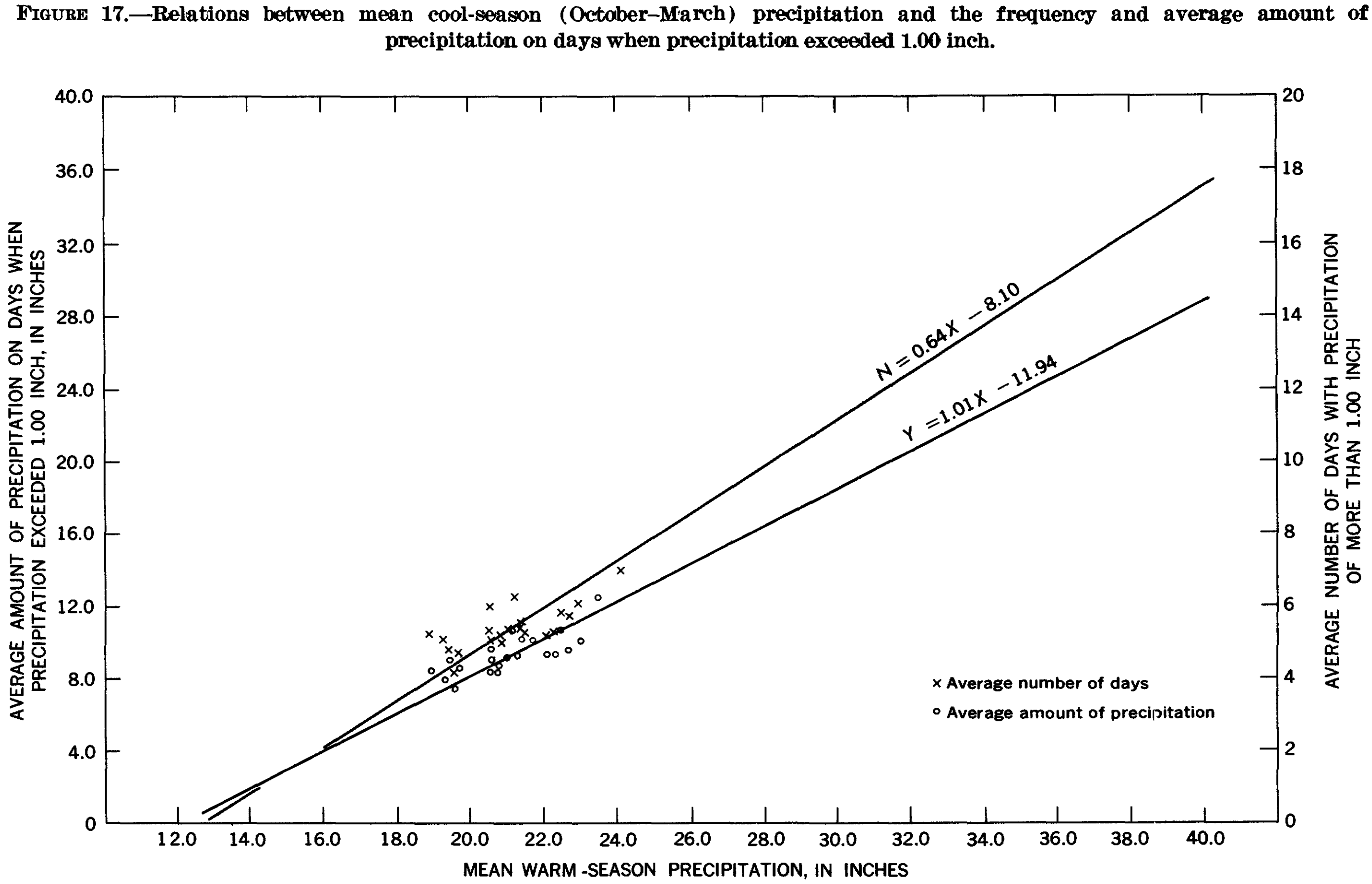


Figure 18.—Relations between mean warm-season (April–September) precipitation and the frequency and average amount of precipitation on days when precipitation exceeded 1.00 inch.

"Fisher-Tippett Type I," fitted by the procedures developed by Gumbel (1958). The relationships were verified by a comparison of concurrent data (15 years of record at 24-hour observation intervals) from the New York City WBO and data from 21 stations on Long Island.

The average 2- and 25-year recurrence-interval amounts were approximately 7 percent lower for the stations on Long Island than for the New York City WBO. There was no definable regional pattern in the 2-year 24-hour values, which are the most reliable values from such a short period of record. When plotted on maps, the higher 2-year 24-hour values showed a slight tendency to occur with the higher values of mean annual precipitation, but the correlation coefficient for the two factors was only 0.33, which was not significant.

The Weather Bureau Office at La Guardia Airport is the station on Long Island with the longest record of precipitation for very short durations—5 minutes, 10 minutes, and so on. Figure 19 shows a comparison of the intensity-frequency curves for the 12 years of concurrent data (1949–60) from that station and the New York City WBO. The similarity of the curves for the two locations indicates that use of the long-record data from the New York City WBO provides reasonable estimates for the Long Island region.

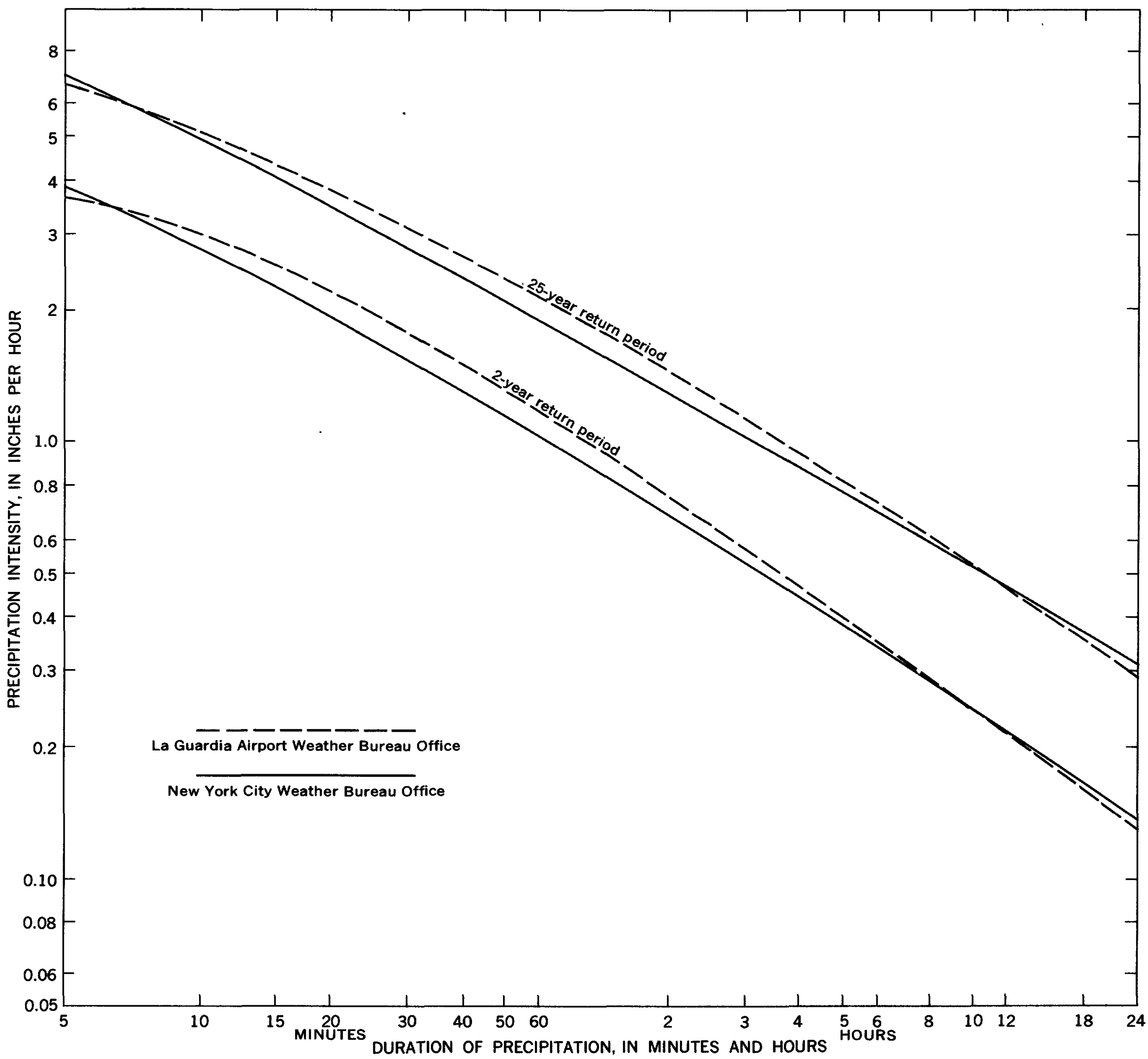


FIGURE 19.—Comparison of the frequency of precipitation intensity for 2-year and 25-year recurrence intervals at the New York City and La Guardia Airport Weather Bureau Offices based on data for the period 1949–60.

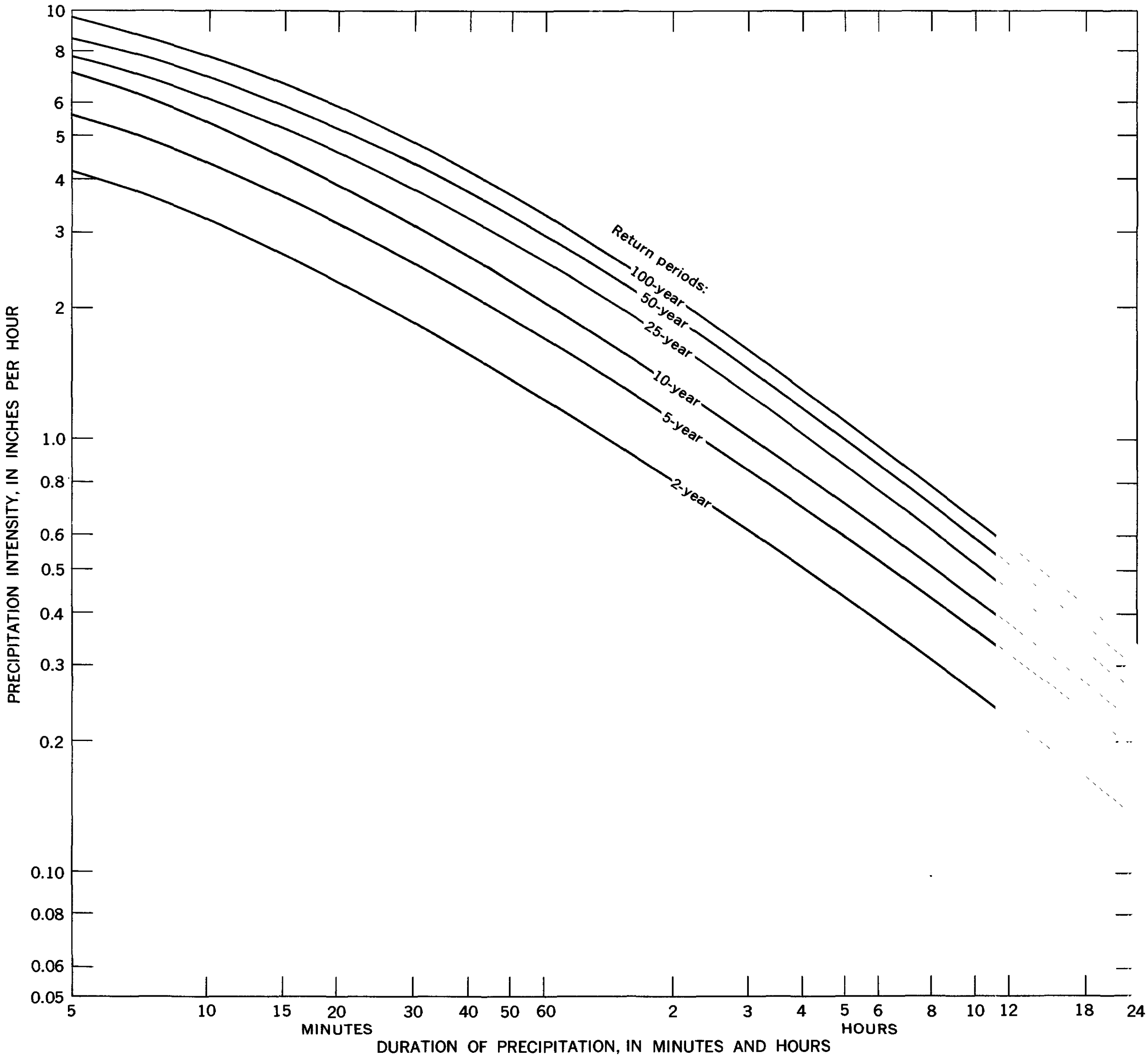


FIGURE 20.—Frequency of precipitation intensity for durations ranging from 5 minutes to 24 hours at the New York City Weather Bureau Office based on data for the period 1903–60.

Figure 20 shows the results of a frequency analysis of the New York City WBO precipitation-intensity data for short durations. The period of record is 1903–60, when the station was located near the southern end of Manhattan Island. In early 1961 the station was moved to its present location in the middle of Manhattan Island. Data from the present location have not been used for this report, inasmuch as the addition of 5 years of record usually will not significantly change the estimates provided by a record of 50 years or more. The precipitation-frequency values for durations ranging from 1 day to 10 days, also using data from the New York City WBO, are shown in figure 21.

The curves of figures 20 and 21 can be used to estimate the recurrence interval of large amounts of precipitation that have occurred over Long Island. Table 1 showed large rainfall amounts associated with hurricanes for several stations on Long Island. The precipitation does not usually occur during the entire observational period; for example, the 2-day total of 5.35 inches measured at Mineola from Hurricane Edna actually occurred during a 19-hour period (an average hourly rate of 0.28 inch). The recurrence interval of this average 0.28 inch-per-hour intensity for the 19-hour duration is between 10 and 15 years (fig. 20). The 10.74 inches measured at Mineola in August 1955 from Hurricane

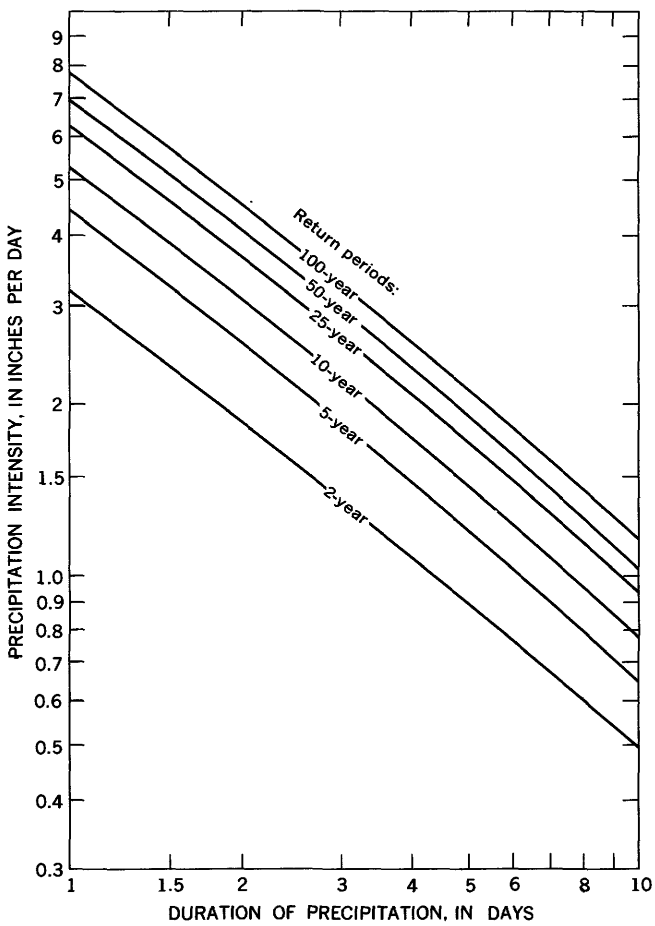


FIGURE 21.—Frequency of precipitation intensity for durations ranging from 1 to 10 days at the New York City Weather Bureau Office based on data for the period 1903–60.

Connie occurred in a period of 33 hours. This was an average daily rate of 7.81 inches, which has a recurrence interval of more than 100 years (fig. 21).

Frequency analysis can be based on either annual-series or partial-duration-series data. The annual series is composed of the maximum value from each year of record for a particular duration. In contrast, the partial-duration series is composed of the n highest values for n years of record; that is, two or more values may be selected from 1 year, and in other years no value may be selected. The curves of figures 19–21 are based on an analysis of annual-series data. If the values that would result from an analysis of a partial-duration series are desired, the indicated values for the 2-, 5-, and 10-year curves should be multiplied by 1.13, 1.04 and 1.01, respectively (Hershfield, 1961; Miller, 1964).

The rainfall-frequency values discussed thus far refer to a single station or to point values. For many applications the average depth over a specified drainage area might be desired instead—for example, to design highway culverts, storm sewers, or other hydrologic structures. There are two basic types of depth-area relations: (1) storm-centered relations and (2) geographically fixed relations. Both types of relationships commonly are presented as curves on a graph. The frequency-derived, geographically fixed, depth-area curves are based on different parts of different storms instead of on the largest amount around the storm centers. Because the area of interest is geographically fixed, a station within this area sometimes measures rainfall near the storm center, sometimes on the outer edges, and sometimes in between. This averaging process results in the geographically fixed curves being flatter than storm-centered curves. This is understandable inasmuch as the greatest rate of change in total precipitation amounts is at the storm center. Each of the two curves (that based on storm-centered relations and that based on geographically fixed relations) is appropriate for particular applications. For the determination of the average depth for a particular rainfall frequency over a geographically fixed drainage basin, the geographically fixed relationship, is, of course, more appropriate.

The curves in figure 22 show the percentage factors to be applied to the point precipitation-intensity values from figure 20, for durations from 30 minutes to 24 hours, to compute the average depth over an area as great as 200 square miles. This relation was developed for the "Rainfall Frequency Atlas of the United States" (Hershfield, 1961). A similar relation to be used with the rainfall-frequency values for durations from 1 through 10 days is shown in figure 23 (Miller, 1964). Both relations were developed using data from dense raingage networks in widely scattered parts of the United States. Although a regional variation was not evident in the data used to develop the curves, the network sampling was not adequate to preclude the possibility of some regional variation. Several of the net-

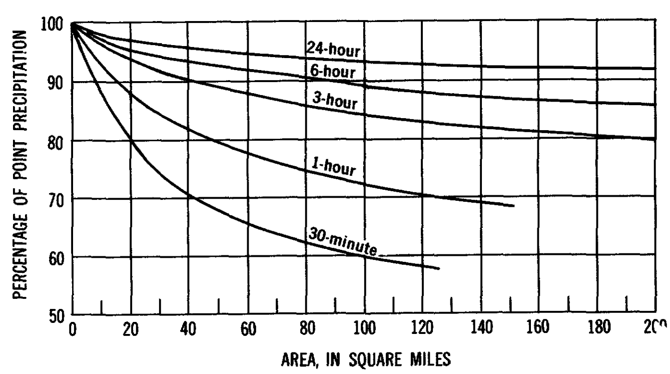


FIGURE 22.—Percentages by which point-precipitation-intensity values for durations between 30 minutes and 24 hours should be reduced to yield average precipitation intensity for various areas. (After Hershfield, 1961.)

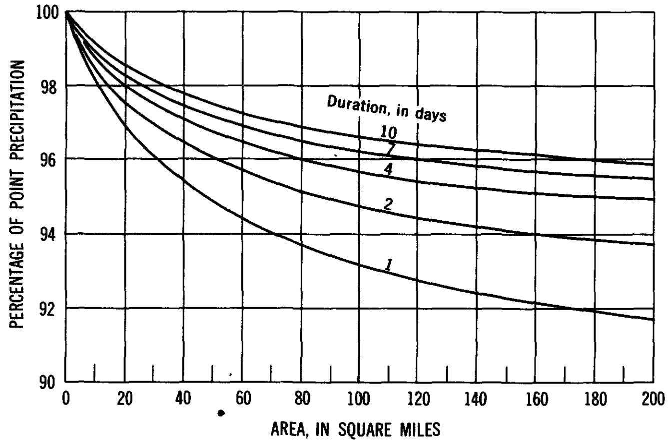


FIGURE 23.—Percentages by which point-precipitation-intensity values for durations between 1 and 10 days should be reduced to yield average precipitation intensity for various areas. (After Miller, 1964.)

works used, however, were in coastal parts of New York, New Jersey, and New England; therefore, the curves probably should adequately reflect the depth-area characteristics for Long Island.

SNOWFALL ON LONG ISLAND

Previous sections of this report have dealth with total precipitation. During the warm-season months, virtually all the precipitation is rain. During the cool season, however, precipitation occurs as snow, mixed snow and rain, as well as rain only. Table 6 shows the mean total snowfall at five stations on and near Long Island. The water equivalent of total snowfall accounts for about 5 to 10 percent of the precipitation that falls in the cool season. On the average, at least 1 inch of snow falls every 8 days in the cool season (U.S. Weather Bureau, 1958) and lesser amounts fall more often. Snow cover to a depth of 1 inch or more occurs on the average of 35 days per year. Table 7 shows the monthly distribution of snowstorms with snow depths of 6 inches or more at the New York City WBO. Most large snowstorms occur after the first of December and before the middle of March; they are most frequent in the first half of February.

SUMMARY

Precipitation on Long Island results from a variety of causes including tropical storms, airmass thunder-

TABLE 6.—*Mean total snowfall for selected stations on and near Long Island, N.Y.*

[Prior to January 1956 "snowfall" includes sleet and hail. Amounts shown are inches of measured snow, not the water equivalent]

Station	Length of record (years)	Mean amounts of snowfall (inches)							
		Monthly							Annual
		Jan.	Feb.	Mar.	Apr.	Oct.	Nov.	Dec.	
Bridgehampton	34	7. 4	7. 4	6. 0	0. 5	Tr.	0. 6	5. 9	27. 8
Hempstead-Garden City	15	8. 1	6. 7	7. 1	. 8	0	. 7	6. 0	29. 4
New York La Guardia Airport	22	6. 8	7. 8	5. 2	. 9	. 1	. 5	6. 7	28. 0
New York Weather Bureau Office	76	7. 3	9. 0	5. 9	1. 0	Tr.	. 9	6. 2	30. 3
Riverhead Research	27	7. 6	6. 4	5. 0	. 7	Tr.	. 3	6. 1	26. 1

TABLE 7.—*Number and periods of occurrence of snowstorms yielding 6 inches or more of snow at New York City station (Weather Bureau Office), 1884–1960*

Depth of snow (inches)	Periods of occurrence												Total occurrences
	November		December		January		February		March		April		
	1–15	16–30	1–15	16–31	1–15	16–31	1–15	16–29	1–15	16–31	1–15	16–30	
6.0–6.9	1	1	4	3	1	3	4	2	5	2	1		27
7.0–7.9		1	4	2	2	4	2		3				18
8.0–8.9		1		2	1		4	1		1	1		11
9.0–9.9					3	2	2	3	2				12
10.0–10.9				2	1	2	3	3		2	1		14
11.0–11.9				1	1		1	1	1				5
12.0–12.9			2					1					3
13.0–13.9										1			1
14.0–14.9				1	1		1		3				6
15.0–15.9							1	1		1			3
16.0–16.9				1									1
17.0–17.9			1			1	1	1					4
Totals [1]	1	3	11	12	10	12	19	13	14	7	3	0	105

[1] In addition to the above, one snowstorm yielding a total of slightly more than 20 inches of snow occurred in the first half of March, and one of slightly more than 25 inches occurred in the last half of December.

storms, and extratropical storms. The mean precipitation is greatest near the slightly elevated central part of Long Island. Two factors are probably most important in producing this geographic distribution of precipitation: (1) The relatively greater distance of this part of the Island from the stabilizing effect of the adjacent bodies of water, and (2) the slightly higher terrain in the central part of the Island. The mean precipitation is characterized by approximately 10 percent greater average depth over the Island in the cool-season months of October–March than in the warm-season months of April–September. The number of days with more than 1.00 inch of precipitation is related to seasonal precipitation amounts, whereas, the number of days with precipitation equal to or less than 1.00 inch is randomly distributed geographically, but shows considerable seasonal variation. Most precipitation over Long Island comes as rain; only about 5–10 percent of the water equivalent of cool-season precipitation is in the form of snow.

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